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Vishal Kumar
Research Scholar, Department of Agronomy, Institute of Agricultural Sciences BHU, Varanasi, Uttar Pradesh, India

RK Singh
Professor, Department of Agronomy, Institute of Agricultural Sciences BHU, Varanasi, Uttar Pradesh, India

Dharminder
Research Scholar, Department of Agronomy, Institute of Agricultural Sciences BHU, Varanasi, Uttar Pradesh, India

Manjeet Kumar
Research Scholar, Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Vishal Kumar
Research Scholar, Department of Agronomy, Institute of Agricultural Sciences BHU, Varanasi, Uttar Pradesh, India

Effect of farm yard manure and Sulphur on production of Indian mustard: A review

Vishal Kumar, RK Singh, Dharminder and Manjeet Kumar

Abstract
The continuous mining of nutrients from soils coupled with inadequate and imbalanced fertilizer use has resulted in emergence of multi nutrient deficiencies. Mainly of six nutrients (N, P, K, S, Zn and B) were observed deficient in Indian soils. For maintaining the soil fertility, application of balance dose fertilizer along with organic manure is necessary. The long-term application of farmyard manure (FYM) has been reported to make nutrients available gradually, in synchrony with plant needs. Farm Yard Manure helps in increasing microbes' population and their activities, which play an important role in easily availability of complex nutrients to the plants. Sulphur is involved directly or indirectly in different metabolic pathways of plants and play important role in biosynthesis of oil, carbohydrates, proteins and fats. Thus now-a-days sulphur is being considered as the fourth major nutrient element after NPK. Application of sulphur and farm yard manure has been reported to have a favorable impact on oil content as well as enhancing productivity of mustard at the same time it maintained the soil fertility status and also helps in keeping soil in good condition.

Keywords: Sulphur, farm yard manure, soil fertility, yield, mustard

Introduction

Rapeseed and mustard (*Brassica juncea* L.) are important oilseed crops, which ranks third in vegetable oils after soybean and palm. Globally, India ranks third (7.0 m tons) after Canada (17.7mtons) and China (15.0 m tons) in production of Rapeseed-mustard (FAOSTAT, 2016) [9]. In India, soybean (34%), groundnut (27%) and rapeseed-mustard (27%) are the major oilseed crops contributing nearly 88% of the total production (Anonymous, 2017) [3]. Its seed contains 37-49% oil. The oil and seeds are broadly used through humans and livestock as different food products and cattle feed (Anonymous, 2011) [2]. The oil and seeds are used as condiment in the preparation of pickles and for flavoring curies and vegetables. The mustard oil is utilized for human consumption throughout northern India in cooking and frying purposes. It is also used in the preparation of hair oils and medicines. The oil cake is used as cattle feed and manure, which contains about 4.9 percent nitrogen, 2.5 percent phosphorus and 1.5% potash (Singh *et al.*, 2014a) [28].

The continuous mining of nutrients from soils coupled with inadequate and imbalanced fertilizer use has resulted in emergence of multi nutrient deficiencies. Mainly at least six nutrients (N, P, K, S, Zn and B) were observed deficient in Indian soils. Sulphur is involved directly or indirectly in different metabolic pathways of plants and play important role in the enzymatic processes including photosynthesis and respiration activities. The involvement of sulphur is an important component of several enzymes and metabolic processes in plants (Lakkineni and Abrol, 1994) [19].

An insufficient S supply can affect yield and quality of the crops, caused by the S requirement for protein and enzyme synthesis (Scherer, 2009) [26]. Sulphur deficiencies have been reported from more than 70 countries worldwide and 120 districts throughout India (Tandon, 1991) [37]. As per latest available data, 41 percent soil samples tested were deficient in available S in India (Singh, 2008) [27]. Sulphur (S) helps in the synthesis of cystein, methionine, chlorophyll, vitamins (B, biotin and thiamine), metabolism of carbohydrates, especially by its effect on the protolytic enzymes (Najar *at al.*, 2011) [20]. It is also necessary for chlorophyll formation and helps in biosynthesis of oil and metabolism of carbohydrates, proteins and fats and thus now-a-days sulphur is being considered as the fourth major nutrient element after NPK (Das *et al.*, 2016) [7].

Farm Yard Manure helps in increasing microbes' population and their activities, which play an important role in easily availability of complex nutrients to the plants. Farm yard manure (FYM) improves the soil physio-chemical properties along with direct release of macro as well as micronutrient; ultimately the crop yields increase (Lakkineni and Abrol, 1994) [19].

The long-term application of organic manures alone in the form of well-rotten and good quality farmyard manure (FYM) has been reported to make nutrients available gradually, in synchrony with plant needs. Besides improving the physico-chemical properties of soil, the application of organic manures can also increase productivity while maintaining a better energy and environmental balance (Singh *et al.,* 2014b) [34].

Effect of FYM on growth and yield attributing characters of mustard

On an average well decomposed farmyard manure contains nitrogen (0.53%), phosphorous (0.22%), potassium (0.59%), iron (2100 mg Kg^{-1}), zinc (61 mg Kg^{-1}), boron (2.2 mg Kg^{-1}) and molybdenum (0.75 mg Kg^{-1}) revealed by Parihar *et al.,* 2012 [23]. The farm yard manure (FYM) application increase the growth and yield parameters of mustard. Apart from providing both macro and micronutrients, FYM increases the availability of added inorganic (manufactured mineral Fertilizers) nutrients resulting in the positive effect on the number of leaves plant^{-1}, thereby increased photosynthetic surface of leaves. Application of FYM at 10 tones ha^{-1} significantly increased the LAI, CGR and dry matter accumulation per plant at almost all the stages. Maximum dry matter accumulation per plant and seed yield were recorded with highest levels of FYM (20 tonnes ha^{-1}), Seed yield was strongly associated with LAI and dry matter accumulation per plant at all the stages (Patel *et al*., 1996) [24]. The sulphur enriched FYM improved average mustard seed yield by almost 20% over control. Less than 25 per cent of RDF with 40 kg S and 10 MT FYM ha^{-1} increase number of siliquae plant^{-1} (381.40), 1000-seed weight (5.52 g), seed yield (1541.5 kg ha^{-1}) and stover yield (5161.0 kg ha^{-1} (Kumar *et al*., 2017) [18]. Application of 100% RDF ($N_{80}P_{40}K_{20}ZN_5S_{20}$) of nutrients and FYM proved the most appropriate fertilizer dose for Ethiopian mustard. Application of FYM @ 10 t ha^{-1} proved the most beneficial for the yield-attributing characters, seed yield, seed oil content, oil yield, NPK sulphur and FYM resulted significantly highest yield was 13.63 q ha^{-1}, seed oil 40.90%, and oil yield 558.7 kg ha^{-1} (Chaurasia *et al.,* 2009) [6]. Application of 60 kg S ha^{-1} and 5.0 kg Zn ha^{-1} along with 10 t FYM ha^{-1} significantly increased the yield attributes and yield of mustard as compared to control but it was at par with the application of 40 kg S ha^{-1} and 5.0 kg Zn ha^{-1} along with 10 t FYM ha^{-1} and maximum economic benefits of gross realization, net realization along with highest BCR of 4.84:1 (Sipai *et al*., 2015) [35]. Progressive increase in level of FYM from control to 6.0 t ha^{-1}resulted significant improvement in growth and yield attributes *viz,* plant height, crop dry matter, primary and secondary branches per plant, number of siliqua plant^{-1}, seeds siliqua^{-1} and test weight, seed yield and net returns over preceding levels during individual years as well as in pooled analysis. It represented a mean seed yield of 12.33 q ha^{-1} that was 8.1 and 24.7% higher than 3.0 t ha^{-1} and control, respectively. Remaining at par with 9 t ha^{-1}, it also fetched 6.0 and 21.9% higher net returns than above levels of FYM (Yadav *et al*., 2013) [42].

Application of 75% NPK and 5 t FYM ha^{-1} produced significantly higher seed (2.09 t ha^{-1}) and stover (6.00 t ha ha^{-1}) yield over either only 100% inorganic fertilizer (4%) or FYM (50%). On an average, seed and stover yields of Indian mustard increased by 37.4 and 45.8, 62.8 and 70.6 and 74.0 and 83.5% with application of 50, 75 and 100% over control, respectively. Application of FYM (5 t ha^{-1}) alone enhanced the seed and stover yield by 20.6 and 24.1% over control (Singh *et al*., 2013) [29]. The plant height, total dry matter accumulation, leaf area index and seed and stover yields were recorded significantly higher when recommended dose of fertilizers (RDF) i.e. 120:17.6:16.6:40, N:P:K:S kg ha^{-1} was applied along with FYM 10 t ha^{-1}, 25 kg $ZnSO_4$ ha^{-1} and seed treatment with *Azotobacter*. On an average, seed yield of mustard increased by 41.2% over alone application of RDF. Application of either FYM or Zn or seed treatment along with RDF enhanced the mustard seed yield by 12.0, 11.5 and 13.0%, respectively over RDF alone (Singh and Pal, 2011) [30]. The results revealed that treatment containing 100% RDF of NPK + FYM 5 MT ha^{-1}+ Sulphur 40 kg ha^{-1} recorded significantly highest mustard grain yield (17.96 q ha^{-1}), oil yield (6.72 q ha^{-1}) and stover yield (43.7 q ha^{-1}) over other treatments (Singh *et al.,* 2017) [33].

Effect of Sulphur on growth and yield attributing characters of mustard

An application of sulphur play a vital role in oilseed crop production through increase in various growth attributes characters of crops like chlorophyll content, leaf area index, number of branches, productive flowers etc. Application of 40 kg S ha^{-1} recorded significantly higher seed yield (19.6 q ha^{-1}) and stover yield (70.9 q ha^{-1}) over 20 kg S ha^{-1} and no sulphur (Neha *et al*., 2014) [21]. The application of 25 per cent of RDF with 40 kg S and 10 MT FYM ha^{-1} increase plant height (174.63 cm), number of branches plant^{-1} (24.47), dry weight (21.47 g) (Kumar *et al.,* 2017) [18]. Maximum plant height was recorded with dual application of sulphur as basal 80% WP @ 1.25 kg ha^{-1} along with foliar sprayed at 75 DAS, closely followed by application of sulphur as basal + 80% WP @ 5 kg ha^{-1} applied with urea broadcasting at 45 DAS and minimum value under farmers practice (Katiyar *et al*., 2014) [13]. Piri and Sharma (2006) [25] revealed that seed and straw yield increased significantly with increasing level of sulphur up to highest level of 45 kg S ha^{-1}. Application of 15, 30 and 45 kg S ha^{-1} increased the seed yield over the control by 9, 16 and 23%, respectively. The entire yield attributes, seeds siliqua^{-1}, 1000-seed weight of Indian mustard increased significantly with increasing doses of sulphur up to 45 kg ha^{-1}, however, the differences between 0 and 15 kg S ha^{-1} for siliquae plant^{-1} and 1000-seed weight and between 15 and 30 kg S ha^{-1} for seeds siliqua^{-1} and 1000-seed weight were not significant. Kumar and Yadav, 2007 [14] observed that a significant response of crop was observed up to 30 kg S ha^{-1} in seed and stover yields. Application of 30 kg S ha^{-1} produced more number of primary branches at 90 days after sowing as compared to control. Number of siliquae plant^{-1} significantly increased up to 30 kg S ha^{-1}. The highest number of siliquae of 334.2 plant^{-1} was recorded with 45 kg S ha^{-1}. The highest number of seeds siliqua^{-1} was recorded at 45 kg S ha^{-1}, which was on at par with that of 30 kg S ha^{-1} and was significantly superior to the control and 15 kg S ha^{-1}. The maximum test weight of 4.63 g 1000 seeds^{-1} was recorded with 45 kg S ha^{-1} and minimum in control (3.84 g 1000 seeds^{-1}). **S**eed and straw yields increased significantly with increasing level of sulphur up to highest level of 60 kg S ha^{-1}; application of 20, 40 and 60 kg S ha^{-1} increased the seed yield over the control by 13.9, 28.1 and 28.4% respectively (Kumar and Trivedi, 2012) [17]. Various levels of sulphur significantly influenced the growth parameters *viz*., plant height and dry weight of plant. The plant height increased significantly with each increment in the dose up to 60 kg ha^{-1}. However, the difference in plant height due to further increase in the dose of sulphur was not significant. Application of 60 kg S ha^{-1}

produced more dry weight of plant at 90 DAS as compared to control and 30 kg S ha^{-1} (Pachauri *et al*., 2012) [22]. The plant growth and productivity increase with increasing level of S and Zn. The application of the S and Zn were highly influenced with the application of 60 kg S ha^{-1} in the combination. The root length, shoot length, number of leaf $plant^{-1}$, number of branch $plant^{-1}$ and crop growth rate was much influenced on these combination. The productivity such as biomass production, number of capsule, seed output and reproductive capacity with grain biological yield also increased with increasing level of S and Zn at S_3 (60 kg ha^{-1}) and Z_3 (1.5 kg ha^{-1}) levels (Baudh and Prashad, 2012) [5].

Effect of FYM and sulphur on oil and protein content

The oil content in seed at par with the increasing of NPK levels whereas; consecutive addition of sulphur and FYM increased oil content. Crop fertilized with 75% recommended dose of fertilizer with sulphur and FYM recorded higher oil content than control. Higher availability of nitrogen may be resulted a higher portion of photo-synthates is delivered to protein formation leaving a potential deficiency of carbohydrates to be degraded to acetyl coenzyme- A for the synthesis of fatty acids (Tripathi *et al.*, 2011) [40]. The increase in oil content with Sulphur fertilization may be attributed to its role in oil synthesis and increase in glucosides (Tripathi *et al., 2010*; Kumar *et al.*, 2006 and Singh *et al.*, 2010) [39, 15, 31]. Availability of Sulphur increased the conversion of fatty acid metabolites to the end product of fatty acid (Jain *et al.*, 1996 and Singh *et al.*, 2011) [10, 30]. It was found that the application of Sulphur and FYM resulted in significant increase in protein content. Sulphur being a constituent of S containing amino acids and increased in protein content. Significant increase in protein content may be due to the increase in availability of Sulphur and nitrogen resulted in protein synthesis (Kumar *et al.*, 2006) [15]. Application of 60 kg S ha^{-1} gave significantly higher seed yield, economics, oil yield, protein yield and nutrients uptake (kg ha^{-1}) than control, 20 and 40 kg S ha^{-1} during experimental years (Verma *et al*., 2012) [41]. Application of 75% NPK in combination with 40 kg S and 10 MT FYM ha^{-1}.Significantly higher oil and protein content were recorded at 75% NPK along with 40 kg S and 10 MT FYM ha^{-1} (Kumar *et al.*, 2017) [18]. The results revealed that treatment containing 100% RDF of NPK + FYM 5MT ha^{-1}+ Sulphur 40 kg ha^{-1} recorded to be more promising to gave significantly and highest oil content (37.66 q ha^{-1}), protein content (21.06%) (Singh *et al.*, 2017) [33]. The oil content and protien in seed increased significantly with successive addition of FYM (10 t ha^{-1}) and sulphur (40 kg ha^{-1}) being highest 30.3%; 31.6% and 7.23%; 7.25% respectively (Alam *et al.*, 2014) [1].

Effect of FYM and sulphur on nutrients content and uptake

The results revealed that each successive increasing level of FYM and mineral nutrients individually and in combination significantly increased the seed and stover yield, content and uptake of nitrogen (N), sulphur (S), zinc (Zn) and iron (Fe) in seed and stover as compared to control. The combined application of FYM and mineral nutrients was found to increase Zn uptake in seed and Fe uptake in stover as compared to their individual application. The highest Zn uptake in seed (87.4 g ha^{-1}) and Fe uptake in stover (868.5 g ha^{-1}) was obtained under 10 t FYM ha^{-1} and 40 kg S ha^{-1}+ 25 kg $ZnSO_4$ ha^{-1}+ 50 kg $FeSO_4$ ha^{-1} (F_2M_4) treatment (Jat *et al*., 2013) [11].

Application of 60 kg S ha^{-1} and 2.5 kg Zn ha^{-1} significantly increased nitrogen, phosphorus; potassium and sulphur content at all the stages of growth and years of experimentation. The seed and stover produced by the crop fertilized with 60 kg S ha^{-1} and 5.0 kg Zn ha^{-1} accumulated significantly higher amount of nutrients (N, P, K and S) except nitrogen and potassium contents in seed where significant increase was recorded only upto 40 kg S ha^{-1} (Jat and Chaudhary, 2012) [12]. The results revealed that treatment containing 100% RDF of NPK + FYM 5MT ha^{-1}+ Sulphur 40 kg ha^{-1} recorded significantly highest uptakes of nitrogen (60.53 kg ha^{-1}), phosphorus (7.6 kg ha^{-1}), potassium (13.47 ha^{-1}) and sulphur (21.01 ppm) by mustard seed were also significantly highest with this treatment whereas treatment consisting 100% RDF of NPK + Sulphur 40 kg appeared to be more promising to gave significantly uptakes of nitrogen (47.42 kg ha^{-1}), phosphorus (8.02 kg ha^{-1}), potassium (60.09 kg ha^{-1}) and sulphur (15.21 ppm) by mustard stover over other treatments (Singh *et al.*, 2017) [33]. The sulphur level of 45 kg ha^{-1} being at par with 30 kg ha^{-1} gave significantly higher seed yield (1.18 and 1.26 tonnes ha^{-1}) stover yield, sulphur uptake (20.07 and 21.27 kg ha^{-1}) and oil and protein content (Kumar *et al.*, 2011) [16].

Effect of FYM and sulphur on soil physical chemical properties

The FYM and sulphur increased the organic matter content, made the soil more porous and aggregated, and resulted in increase of water holding capacity and deacrease in soil mechanical impedance (Alam *et al.*, 2014) [1]. The increase application of zinc and sulphur can reduce the soil pH and application of FYM @ rate of 10 t ha^{-1} recorded the maximum soil moisture per cent and water holding capacity. Alkalinity and poor water holding capacity problems of the soil can be effectively managed by the application of FYM (10 t ha^{-1}) along with sulphur or zinc. Higher yield can be attained by great availability of moisture and mobility of the nutrient (Sipai *et al.*, 2017) [36].

Effect of FYM and sulphur on soil microbial population

The numbers of total bacteria were not significantly different between the chemical fertilizer (CF) - and CF + FYM-soils, while those of culturable bacteria were two to six times higher in the CF + FYM-soil than in the CF-soil. (Toyota and Kuninaga, 2006) [38].

Microbial populations had a higher concentration in the bottom layers of the soil columns and a lower concentration in the top layers. Our results suggest that elemental sulphur application in tropical alkaline soils may be a good alternative for the amending of soil chemical properties and it has beneficial effects on sulphur-oxidizer microorganisms; however it had inhibitory effects on fungi populations (Aguirre *et al*., 1999) [4]. When compared to non sulphur treatments, sulphur applied treatments were superior in available macro and micro nutrient contents in soil. Application of higher doses of fertilizers in combination with sulphur significantly influenced the microbial properties. Treatments, which received 125 and 150% RDF + S @ 30 kg ha^{-1} were at par and higher in microbial activity over the 100% RDF treatment (Deekshitha *et al*., 2017) [8].

Conclusion

From the above enumeration, it may be concluded that combination of sulphur and farm yard manure are essential for mustard production, as well as for good soil health in long run. It plays a key role in proper growth and development of mustard. It is proved that sulphur is fourth essential element for growth and development of mustard. FYM is not only supply all macro and micro nutrient but is also play a vital role in maintaining and improving the soil biological, chemical and physical properties of soil.

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